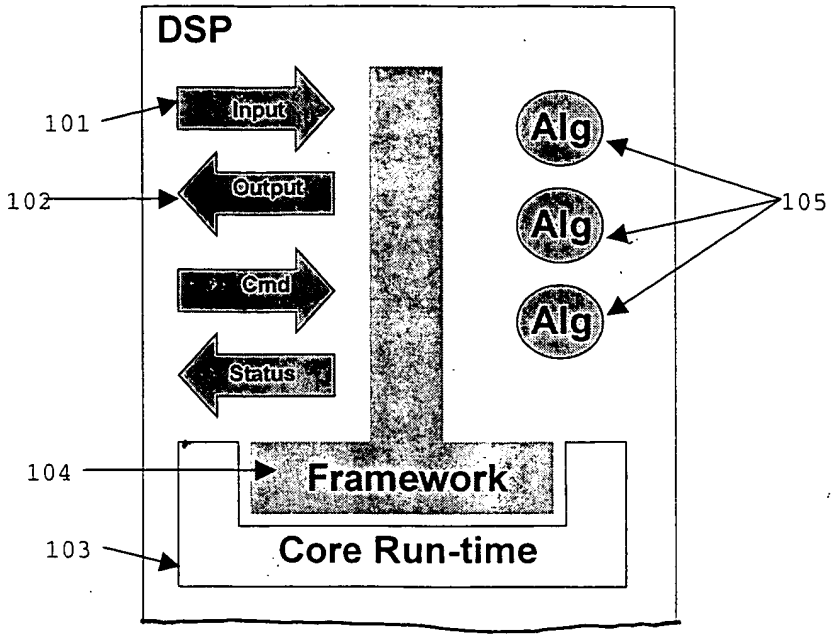


Figure 1A

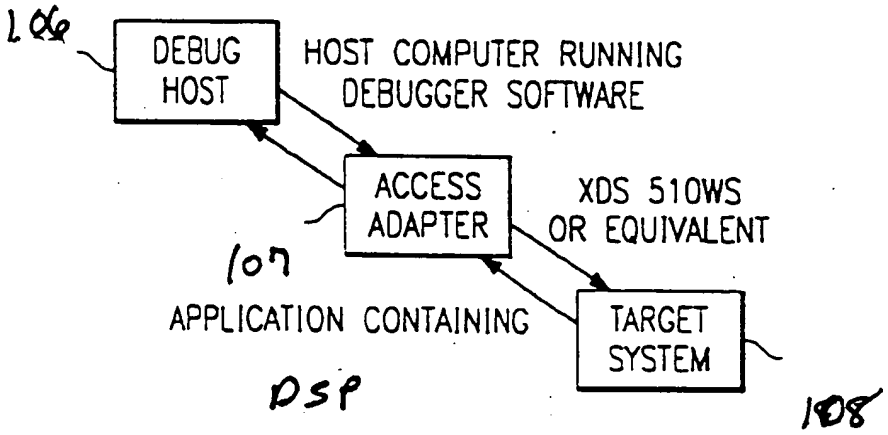


Figure 1B

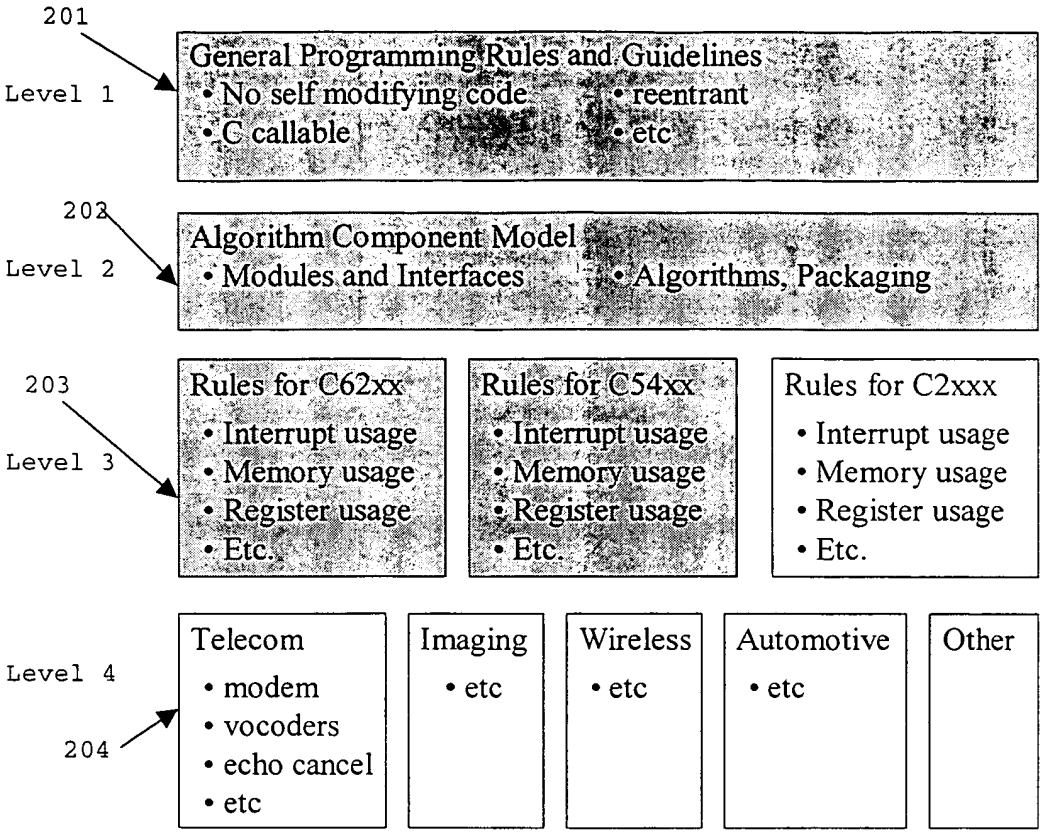


Figure 2

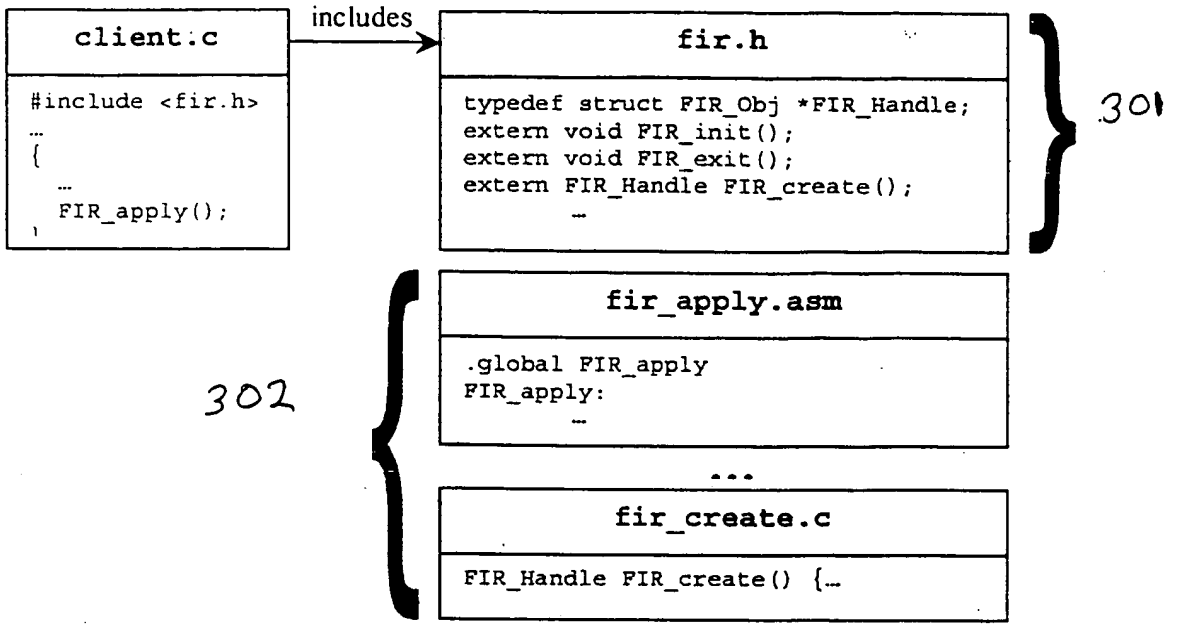


Figure 3

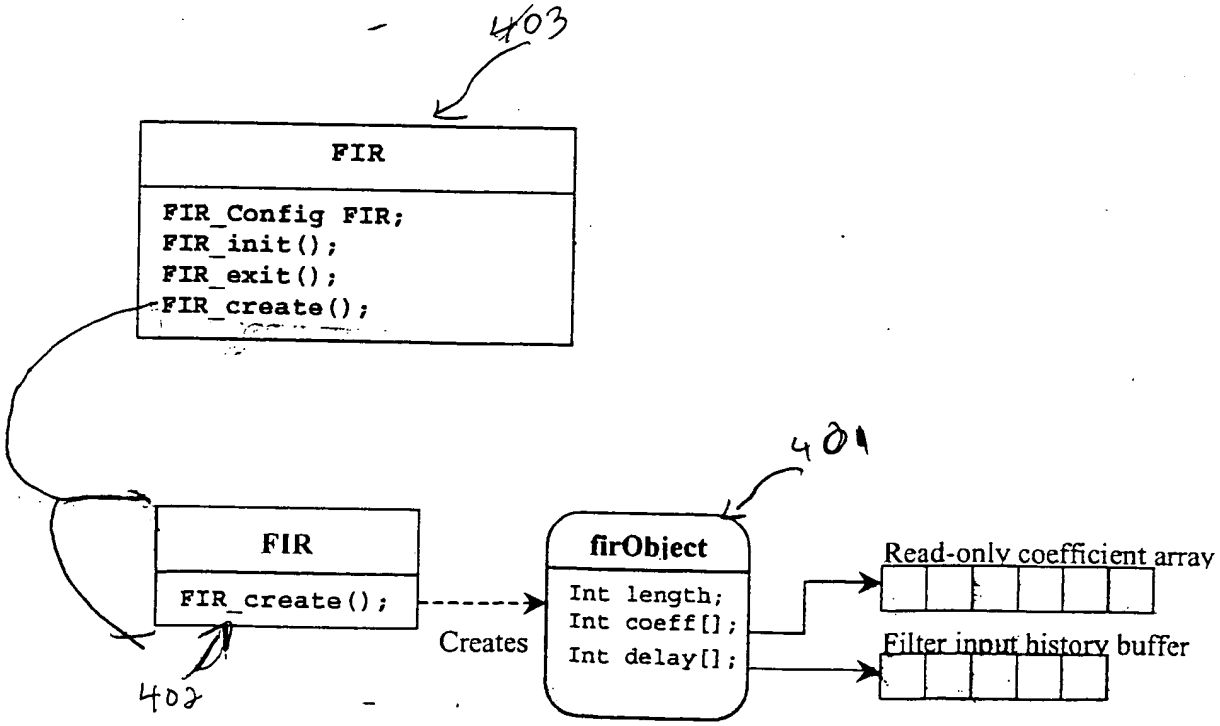


Figure 4

```
void FIR_init(void)
{
}

void FIR_exit(void)
{
}
```

501

```
typedef FIR_Params {      /* FIR_Obj creation parameters */
    int frameLen;         /* input/output frame length */
    int *coeff;           /* pointer to filter coefficients */
} FIR_Params;

FIR_Params FIR_PARAMS = { 64, NULL }; /* default parameters */

typedef struct FIR_Obj { /* FIR_Obj definition */
    int hist[16];         /* previous input value */
    int frameLen;         /* input frame length */
    int *coeff;
} FIR_Obj;
```

505

```
FIR_Handle FIR_create(FIR_Obj *fir, const FIR_Params *params)
{
   if (fir != NULL) {
     if (params == NULL) { /* use defaults if params is NULL */
        params = &FIR_PARAMS;
     }
     fir->frameLen = params->frameLen;
     fir->coeff = params->coeff;
     memset(fir->hist, 0, sizeof (fir->hist));
   }

   return (fir);
}
```

502

```
void FIR_delete(FIR_Handle fir)
{
}
```

503

```
void FIR_apply(FIR_Handle fir, int in[], int out[])
{
   int i;

   /* filter data using coefficients fir->coeff and
      history fir->hist */
   for (i = 0; i < fir->frameLen; i++) {
      out[i] = filter(in[i], fir->coeff, fir->hist);
   }
}
```

504

Fig. 5

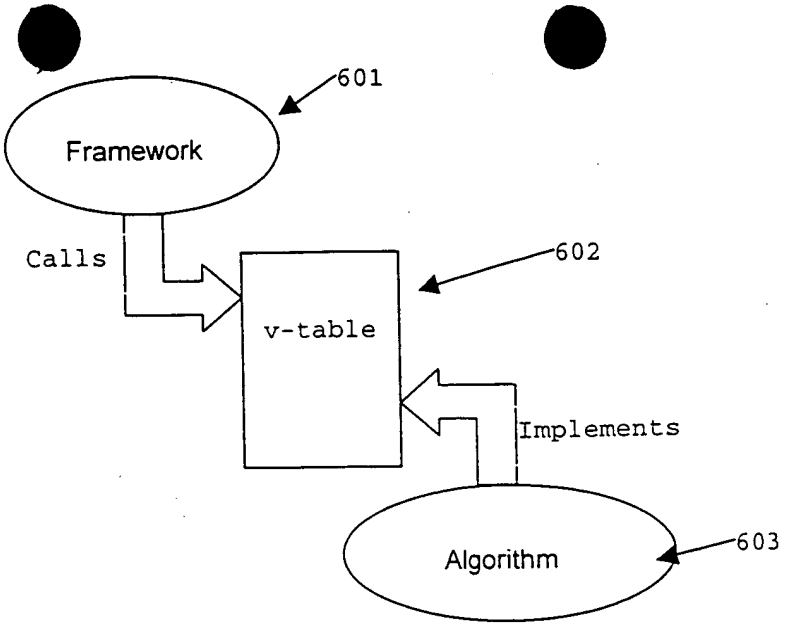


Figure 6

```
/*--------------------------*/
/* TYPES AND CONSTANTS */
/*--------------------------*/
#define IALG_DEFMEMRECS 4
#define IALG_OBJMEMREC 0
#define IALG_SYSCMD 256
#define IALG_EOK 0
#define IALG_EFAIL -1

typedef enum IALG_MemAttrs {
      IALG_SCRATCH,
      IALG_PERSIST,
      IALG_WRITEONCE
} IALG_MemAttrs;

#define IALG_MPROG 0x0008
#define IALG_MXTRN 0x0010
/*
* ======== IALG_MemSpace ========
*/

typedef enum IALG_MemSpace {
      IALG_EPROG = IALG_MPROG | IALG_MXTRN,
      IALG_IPROG = IALG_MPROG,
      IALG_ESDATA = IALG_MXTRN + 0,
      IALG_EXTERNAL = IALG_MXTRN + 1,
      IALG_DARAM0 = 0,
      IALG_DARAM1 = 1,
      IALG_SARAM = 2,
      IALG_SARAM0 = 2,
      IALG_SARAM1 = 3
} IALG_MemSpace;

typedef struct IALG_MemRec {
      Int size;
      Int alignment;
      IALG_MemSpace space;
      IALG_MemAttrs attrs;
      Void *base;
} IALG_MemRec;
```

```
/* default number of memory records */
/* memory record index of instance object */
/* minimum "system" IALG_Cmd value */
/* successful return status code */
/* unspecified error return status code */

/* scratch memory */
/* persistent memory */
/* write-once persistent memory */

/* program memory space bit */
/* external memory space bit */

/* external program memory */
/* internal program memory */
/* off-chip data memory (accessed sequentially) */
/* off-chip data memory (accessed randomly) */
/* dual access on-chip data memory */
/* dual access on-chip data memory */
/* single access on-chip data memory */
/* block 0, equivalent to IALG_SARAM */
/* block 1, if independant blocks required */

/* 'sizeof' memory request in MAUs (minimum address-able unit)*/
/* alignment requirement (in MAUs) */
/* allocation space */
/* memory attributes */
/* base address of allocated buf */
```

Figure 7A

```
/*
 * ======== IALG_Obj ========
 * Algorithm instance object definition
 *
 * All XDAIS algorithm instance objects *must* have this structure as their first element. However, they do not
 * need to initialize it; initialization of this sub-structure is done by the "framework".
 */
typedef struct IALG_Obj {
    struct IALG_Fxns *fxns;
} IALG_Obj;

/*
 * ======== IALG_Handle ========
 * Handle to an algorithm instance object
 */
typedef struct IALG_Obj *IALG_Handle;
/*
 * ======== IALG_Params ========
 * Algorithm instance creation parameters
 * All XDAIS algorithm parameter structures *must* have a this as their first element.
 */
typedef struct IALG_Params {
    Int size; /* number of MAUs (i.e. the 'sizeof') the structure */
} IALG_Params;

/*
 * ======== IALG_Status ========
 * Pointer to algorithm specific status structure
 * All XDAIS algorithm status structures *must* have this as their first element.
 */
typedef struct IALG_Status {
    Int size; /* number of MAUs (i.e. the 'sizeof') the structure */
} IALG_Status;

/*
 * ======== IALG_Cmd ========
 * Algorithm specific command. This command is used in conjunction with IALG_Status to get and set algorithm
 * specific attributes via the algControl method.
 */
typedef unsigned int IALG_Cmd;
```

705 707 703 704

Figure 7B

8/30

```
typedef struct IALG_Fxns {
      Void          *implementationId;
      Void          (*algActivate)(IALG_Handle);
      Int           (*algAlloc)(const IALG_Params *, struct IALG_Fxns **, IALG_MemRec *);
      Int           (*algControl)(IALG_Handle, IALG_Cmd, IALG_Status *);
      Void          (*algDeactivate)(IALG_Handle);
      Int           (*algFree)(IALG_Handle, IALG_MemRec *);
      Int           (*algInit)(IALG_Handle, const IALG_MemRec *, IALG_Handle, const
IALG_Params          *);
      Void          (*algMoved)(IALG_Handle, const IALG_MemRec *, IALG_Handle, const
IALG_Params          *);
      Int           (*algNumAlloc)(Void);
} IALG_Fxns;
```

Figure 7C

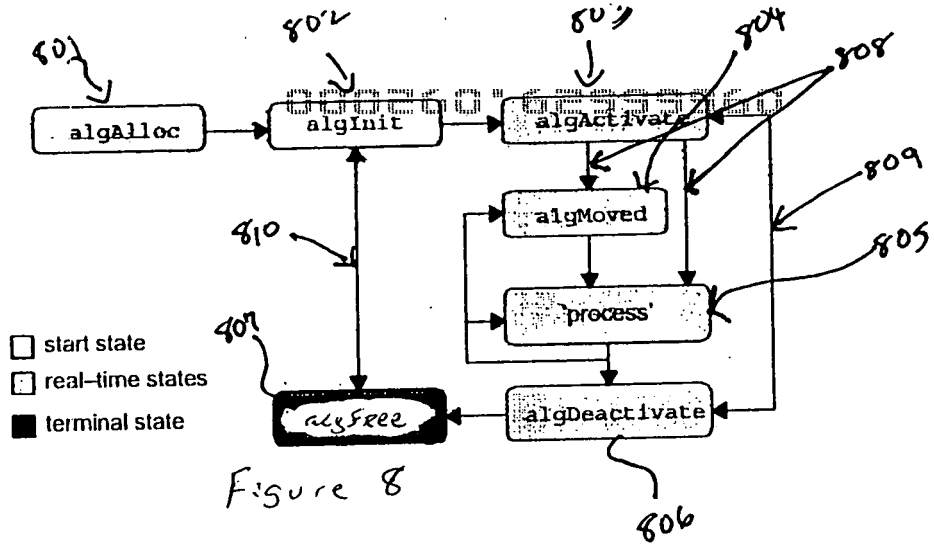


Figure 8

```
client()
{
      FIR_Params stdParams;
      FIR_TI_Params tiParams;

      stdParams = FIR_PARAMS;                    /* initialize all fields to defaults */
      stdParams.coeff = …;                       /* initialize selected parameters */
      fxns->algAlloc(&stdParams, …);             /* pass parameters to algorithm */

      tiParams = FIR_TI_PARAMS;                  /* initialize all fields to defaults */
      tiParams.coeff = …;                        /* initialize selected parameters */
      fxns->algAlloc(&tiParams, …);              /* pass parameters to algorithm */
}
Int FIR_TI_algAlloc(IALG_Params *clientParams, …)
{
      FIR_TI_Params params = FIR_TI_PARAMS;

      /* client passes in parameters, use them to override defaults */
      if (clientParams != NULL) {
      memcpy(&params, clientParams, clientParams->size);

      }

      /* use params as the complete set of parameters */
            :

}
```

Figure 9

```
#define MAXMEMRECS  16

typedef struct ALG_Obj {
    IALG_Fxns     fxns;          /* algorithm functions */
} ALG_Obj;

IALG_Handle ALG_create(IALG_Fxns *fxns, IALG_Params *params)
{
    IALG_MemRec   memTab[MAXMEMRECS];
    IALG_Handle   alg = NULL;
    Int           n;

    if (fxns->algNumAlloc() <= MAXMEMRECS) {
        n = fxns->algAlloc(params, memTab);
        if (allocMemory(memTab, n)) {

    alg = (IALG_Handle)memTab[0].base;
    alg->fxns = fxns;
    if (fxns->algInit(alg, memTab, params) != IALG_EOK) {
        fxns->algFree(alg, memTab);
        freeMemory(memTab, n);
        alg = NULL;
    }
        }
    }

    return (alg);
}

Void ALG_delete(IALG_Handle alg)
{
    IALG_MemRec memTab[MAXMEMRECS];
    Int n;

    n = alg->fxns->algFree(alg, memTab);
    freeMemory(memTab, n);
}
```

1001

1002

Figure 10

```
Void FIR_apply(FIR_Handle alg, Int *in[], Int *out[])
{
    /* do app specific initialization of scratch memory */
    if (alg->fxns->ialg.algActivate != NULL) {
        alg->fxns->ialg.algActivate(alg);
    }

    /* filter data */
    alg->fxns->filter(alg, in, out);

    /* do app specific store of persistent data */
    if (alg->fxns->ialg.algDeactivate != NULL) {
        alg->fxns->ialg.algDeactivate(alg);
    }
}
```

Figure 11

```
typedef struct EncoderObj {
    IALG_Obj ialgObj;    /* IALG object MUST be first field */
    Int *workBuf;        /* pointer to on-chip scratch memory */
    Int *historyBuf;     /* previous frame's data in ext mem */
    ... ;
} EncoderObj;

    Void algActivate(IALG_Handle handle)
    {
        EncoderObj *inst = (EncoderObj *)handle;

        /* copy history to beginning of on-chip working buf */
        memcpy(inst->workingBuf, inst->histBuf, HISTSIZE);
    }

    Void encode(IALG_Handle handle,
                    Void *in[], Void *out[])
    {
        EncoderObj *inst = (EncoderObj *)handle;

        /* append input buffer to history in on-chip workBuf */
        memcpy(inst->workBuf + HISTSIZE, in, HISTSIZE);

        /* encode data */
        ...
        /* move history to beginning of workbuf for next frame */
        memcpy(inst->workBuf, inst->workingBuf + FRAMESIZE, HISTSIZE);
    }

    Void algDeactivate(IALG_Handle handle)
    {
        EncoderObj *inst = (EncoderObj *)handle;

        /* save beginning of on-chip workBuf to history */
        memcpy(inst->histBuf, inst->workingBuf, HISTSIZE);
```

1201

1202

Fig 12

```
typedef struct EncoderObj
      IALG_Obj    ialgObj                    /* IALG object MUST be first field */
      Int         *workBuf;                  /* pointer to on-chip scratch memory */
      Int         workBufLen;                /* expressed in words per frame */
      … ;
} EncoderObj;

typedef struct EncoderParams {
      Int frameDuration;                     /* expressed in ms per frame */
};
EncoderParams ENCODERATTRS = {5};            /* default parameters */

Int algAlloc(IALG_Params *algParams, IALG_Fxns **p, IALG_MemRec memTab[])
{
      EncoderParams *params = (EncoderParams *)algParams;
      if (params == NULL) {
            params = &ENCODERATTRS;          /* use default parameters */
      }
      memTab[0].size = sizeof (EncoderObj);
      memTab[0].alignment = 1;
      memTab[0].type = IALG_PERSIST;
      memTab[0].space = IALG_EXTERNAL;

      memTab[1].size = params->frameDuration * 8 * sizeof(int);
      memTab[1].alignment = 1;               /* no alignment */
      memTab[1].type = IALG_PERSIST;
      memTab[1].space = IALG_DARAM;          /* dual-access on-chip */

      return (2);
}
```

1301 1302 1303 1304

Fig. 13

14/30

Example

```
typedef struct EncoderStatus {
   Bool voicePresent;  /* voice in current frame? */
   ... ;
} EncoderStatus;

typedef enum {EncoderGetStatus, ...} EncoderCmd;

Void algControl(IALG_Handle handle,
                IALG_Cmd cmd, IALG_Status *status)
{
   EncoderStatus *sptr = (EncoderStatus *)status;

   switch ((EncoderCmd)cmd) {
      case EncoderGetStatus:
         sptr->voicePresent = ...;
         ...
      case EncoderSetMIPS:
         ...
   }
}
```

Fig. 14

```
typedef struct EncoderObj {
      IALG_Obj    ialgObj                    /* IALG object MUST be first field */
      Int         *workBuf;
      Int         workBufLen;
      ... ;
} EncoderObj;
Int algFree(IALG_Handle handle, IALG_MemRec memTab[])
{
      EncoderObj *inst = (EncoderObj *)handle;

      algAlloc(NULL, memTab);                 /* get default values first */

      memTab[1].size = inst->workBufLen * sizeof(Int);
      memTab[1].base = (Void *)inst->workBuf;
      return(2);
}

Int algAlloc(IALG_Params *params, IALG_MemRec memTab[])
{
      memTab[0].size = sizeof (EncoderObj);
      memTab[0].alignment = 1;
      memTab[0].type = IALG_PERSIST;
      memTab[0].space = IALG_EXTERNAL;

      memTab[1].size = 80;                    /* 10ms @ 8KHz */
      memTab[1].alignment = 1;                /* no alignment */
      memTab[1].type = IALG_PERSIST;
      memTab[1].space = IALG_DARAM;           /* dual-access on-chip */

      return (2);

}
```

FIG 15

```
typedef struct EncoderObj {
      IALG_Obj    ialgObj                  /* IALG object MUST be first field */
      Int         workBuf;                 /* pointer to on-chip scratch memory */
      Int         workBufLen;              /* workBuf length (in words) */
      … ;
} EncoderObj;

Int algInit(IALG_Handle handle,
            IALG_MemRec memTab[], IALG_Handle p, IALG_Params *algParams)
{
      EncoderObj *inst = (EncoderObj *)handle;
      EncoderParams *params = (EncoderParams *)algParams;

      if (params == NULL) {
            params = &ENCODERATTRS;                    /* use default parameters */

      }

      inst->workBuf = memTab[1].base;
      inst->workBufLen = params->frameDuration * 8;
      …

      return (IALG_EOK);
}
```

Fig 16

```
typedef struct EncoderObj {
    IALG_Obj ialgObj  /* IALG object MUST be first field */
    int workBuf;      /* pointer to on-chip scratch memory */
    Int workBufLen;   /* workBuf length (in words) */
    ... ;
} EncoderObj;

algMoved(IALG_Handle handle,
             IALG_Params *algParams, IALG_MemRec memTab[])
{
    EncoderObj *inst = (EncoderObj *)handle;

    inst->workBuf = memTab[1].base;
```

1701

Figure 17

```
#define NUMBUF   3          /* max number of my memory requests */
extern IALG_Fxns *subAlg;  /* sub-algorithm used by this alg */

Int algNumAlloc(Void)
{
    return (NUMBUF + subAlg->algNumAlloc());
}

Int algAlloc(const IALG_Params *p, struct IALG_Fxns **pFxns,
             IALG_MemRec memTab)
{
    Int n;

    /* initialize my memory requests */
    ...
    /* initialize sub-algorithm's requests */
    n = subAlg->algAlloc(..., memTab);
    return (n + NUMBUF);
}
```

1801

Figure 18

```
/*----------------------------*/
/*    TYPES AND CONSTANTS     */
/*----------------------------*/
#define IRTC_ENTER      0
#define IRTC_CLASS1     1
#define IRTC_CLASS2     2
#define IRTC_CLASS3     3
#define IRTC_CLASS4     4
#define IRTC_CLASS5     5
#define IRTC_CLASS6     6
#define IRTC_CLASS7     7

/*
 *  ======== IRTC_Handle ========
 *  Handle to module's trace instance object
 */
typedef struct IRTC_Obj *IRTC_Handle;

/*
 *  ======== IRTC_Mask ========
 */
typedef LgUns IRTC_Mask;

/*
 *  ======== IRTC_Fxns ========
 */
typedef struct IRTC_Fxns {
    Void        *implementationId;
    Void        (*rtcBind)(LOG_Obj *log);
    IRTC_Mask   (*rtcGet)(IRTC_Handle);
    Void        (*rtcSet)(IRTC_Handle, IRTC_Mask mask);
} IRTC_Fxns;
```

1901

Fig. 19

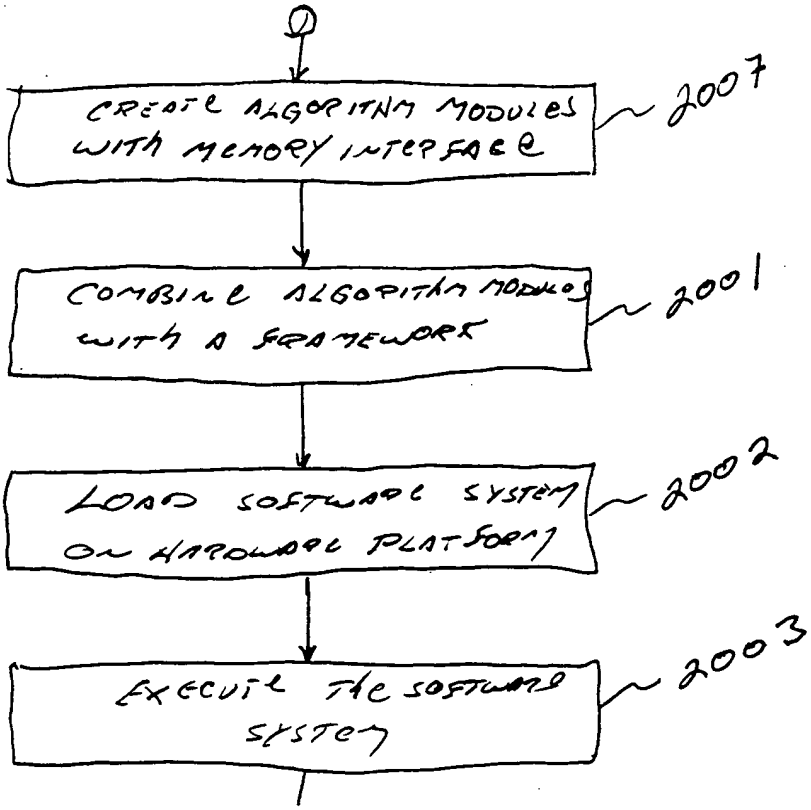


FIG 20A

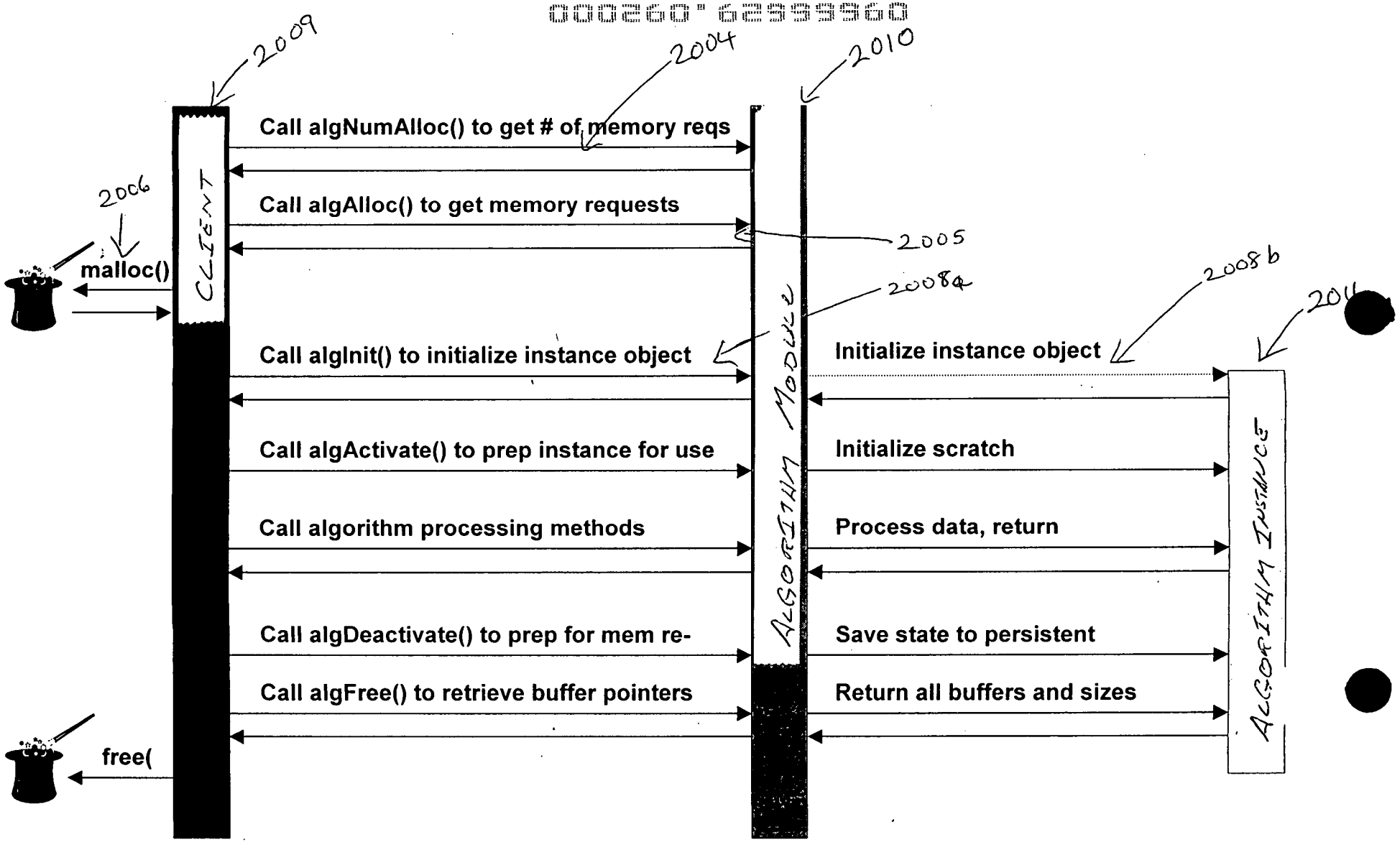

2009
2004
2010
CLIENT
ALGORITHM MODULE
ALGORITHM INSTANCE
2006
malloc()
free(
2005
2008a
2008b
Call algNumAlloc() to get # of memory reqs
Call algAlloc() to get memory requests
Call algInit() to initialize instance object
Initialize instance object
Call algActivate() to prep instance for use
Initialize scratch
Call algorithm processing methods
Process data, return
Call algDeactivate() to prep for mem re-
Save state to persistent
Call algFree() to retrieve buffer pointers
Return all buffers and sizes

Fig. 20B

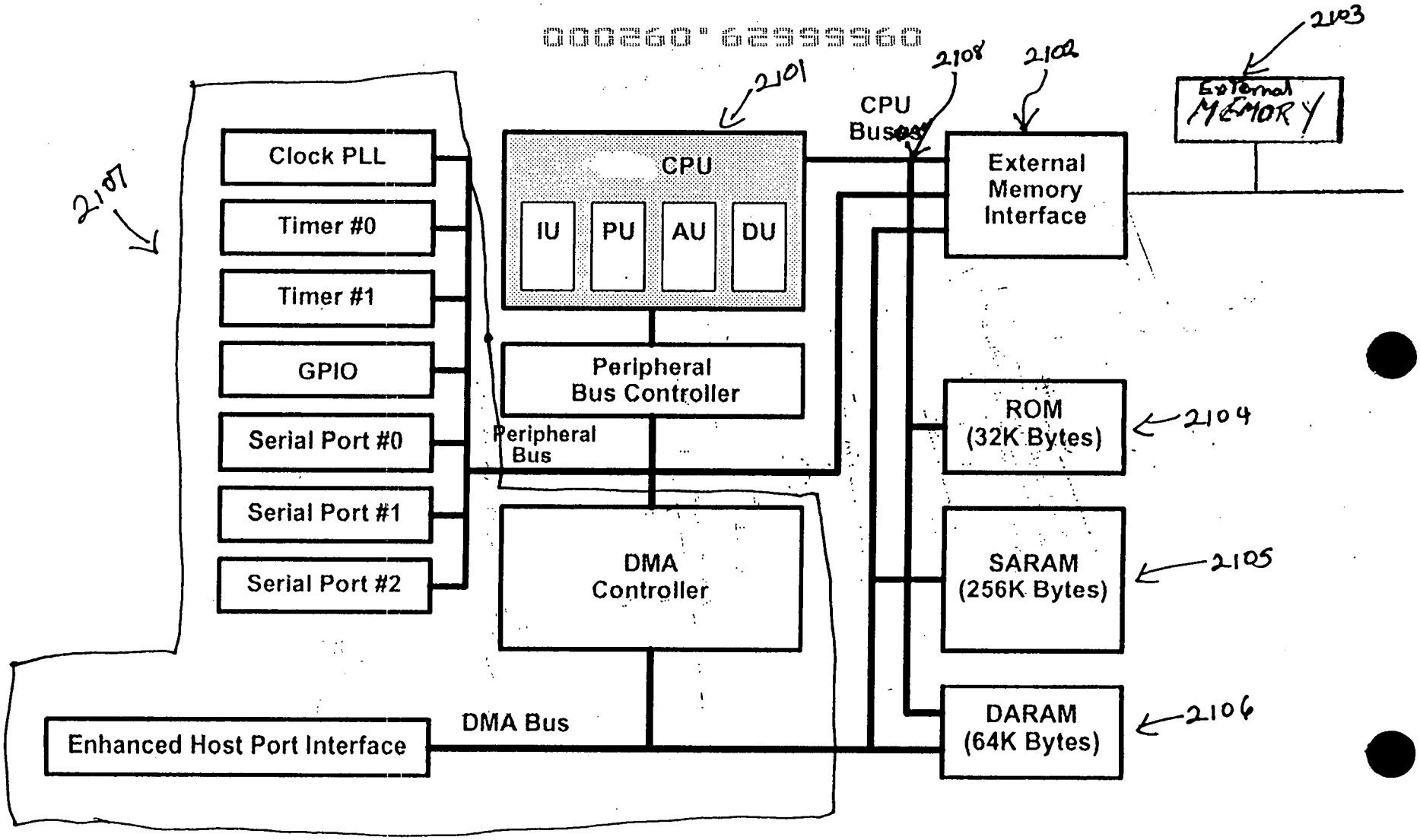

2103
External MEMORY
2101
2108
2102
CPU Bus
CPU
IU
PU
AU
DU
External Memory Interface
2107
Clock PLL
Timer #0
Timer #1
GPIO
Serial Port #0
Serial Port #1
Serial Port #2
Peripheral Bus Controller
Peripheral Bus
DMA Controller
ROM (32K Bytes)
2104
SARAM (256K Bytes)
2105
DARAM (64K Bytes)
2106
DMA Bus
Enhanced Host Port Interface

Figure 21

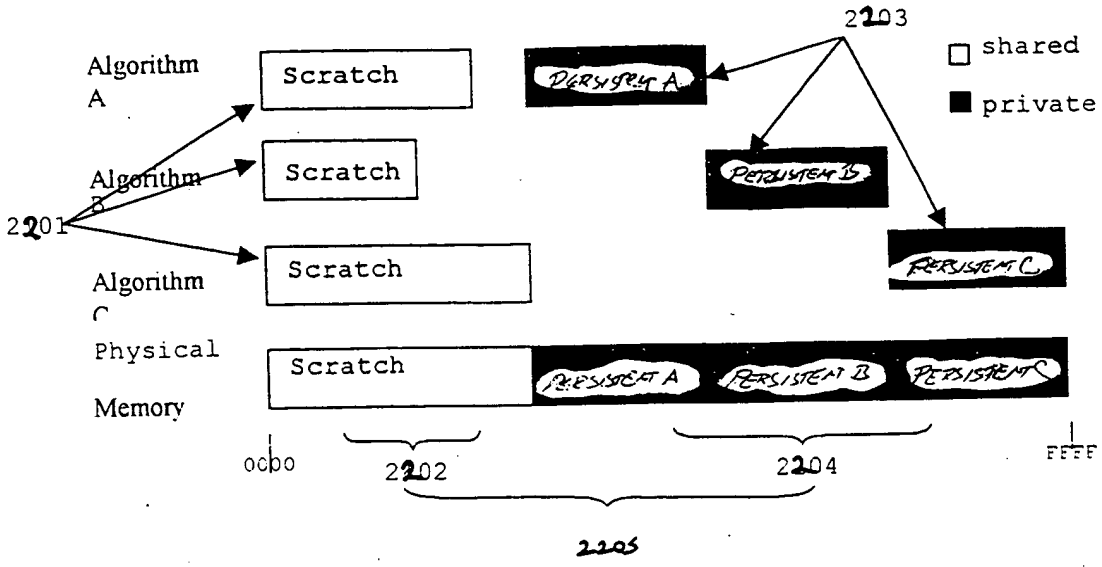


Fig. 22

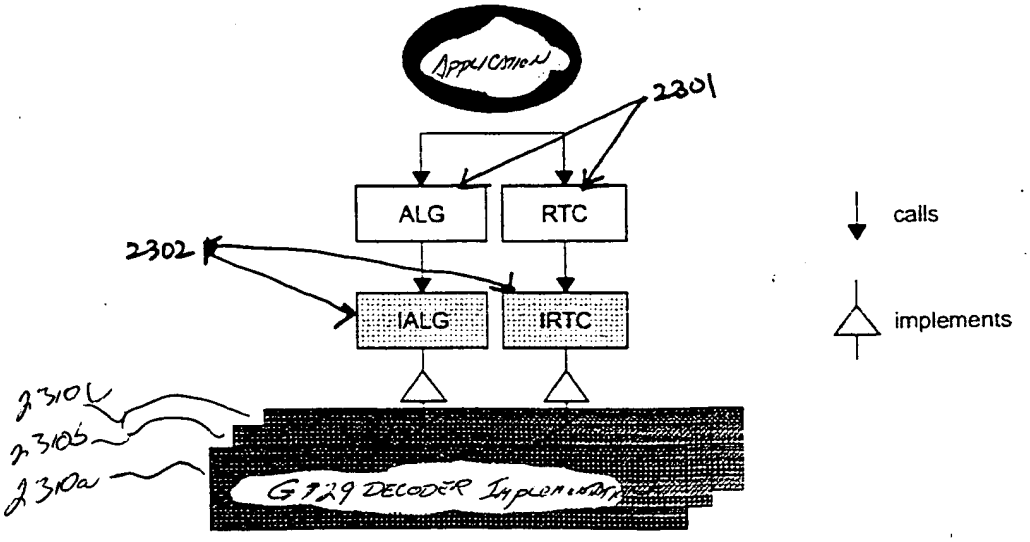


Fig. 23A

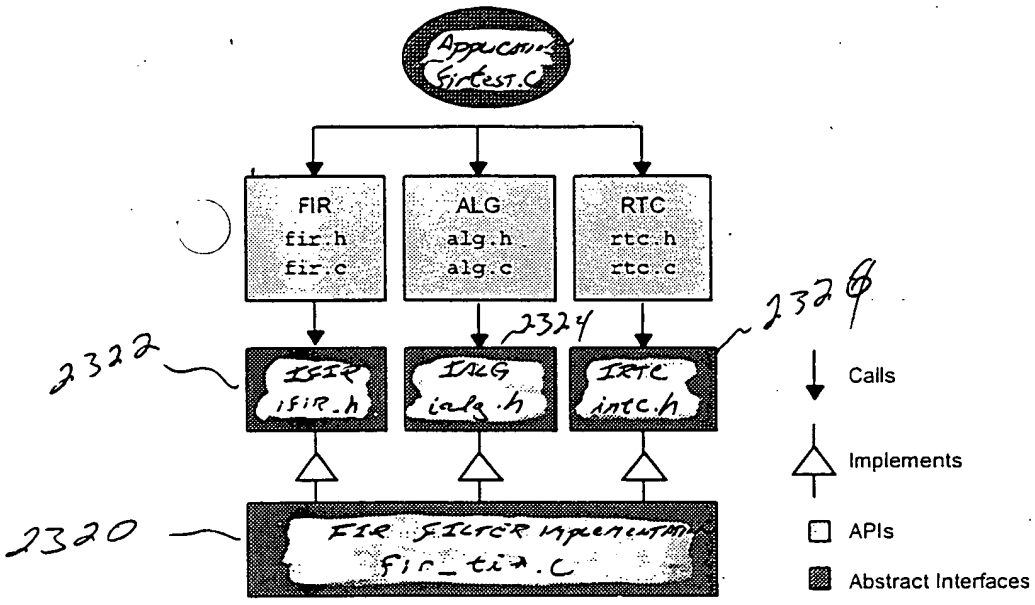

Application
firtest.c
FIR
fir.h
fir.c
ALG
alg.h
alg.c
RTC
rtc.h
rtc.c
2322
2324
2326
IFIR
ifir.h
IALG
ialg.h
IRTC
irtc.h
2320
FIR FILTER implementation
fir_ti.c
Calls
Implements
APIs
Abstract Interfaces

Fig 23B

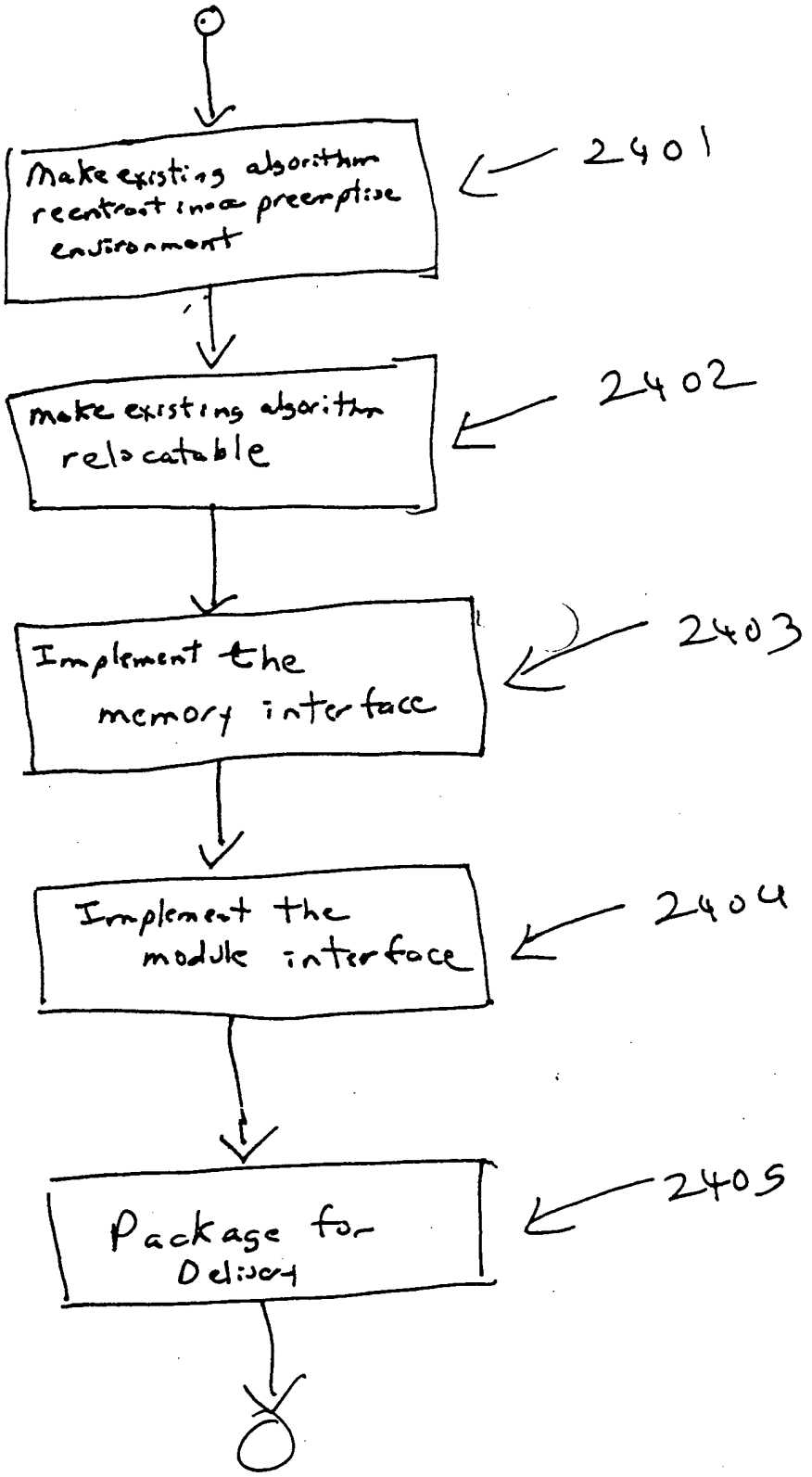

Make existing algorithm reentrant in a preemptive environment
2401
make existing algorithm relocatable
2402
Implement the memory interface
2403
Implement the module interface
2404
Package for Delivery
2405

Figure 24

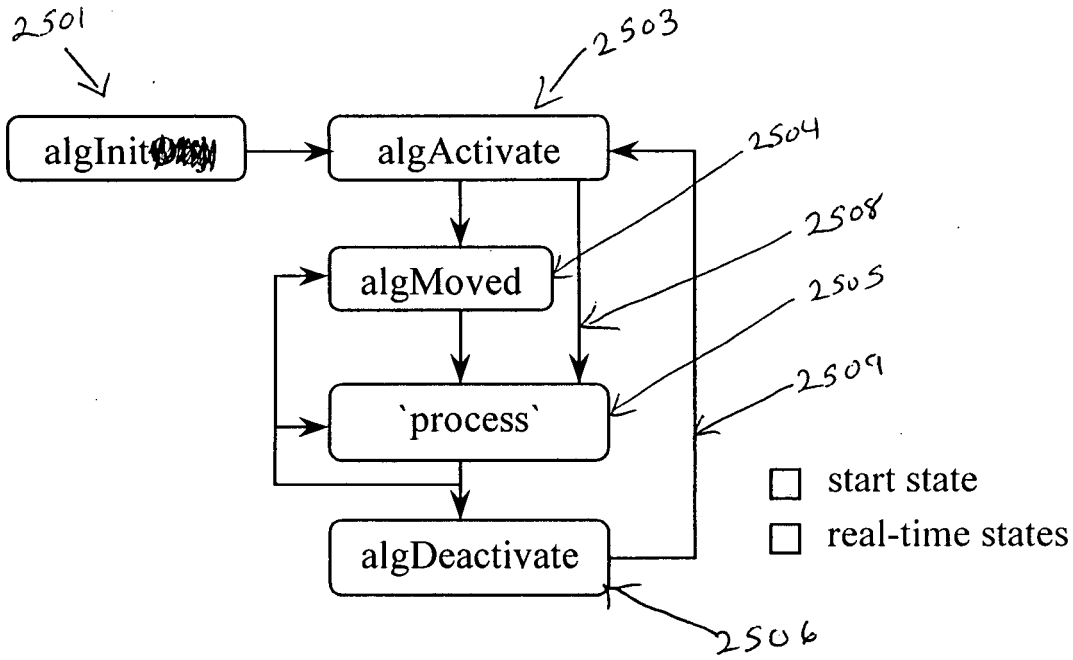

2501
2503
algInit
algActivate
2504
2508
algMoved
2505
2509
`process`
start state
real-time states
algDeactivate
2506

Fig. 25

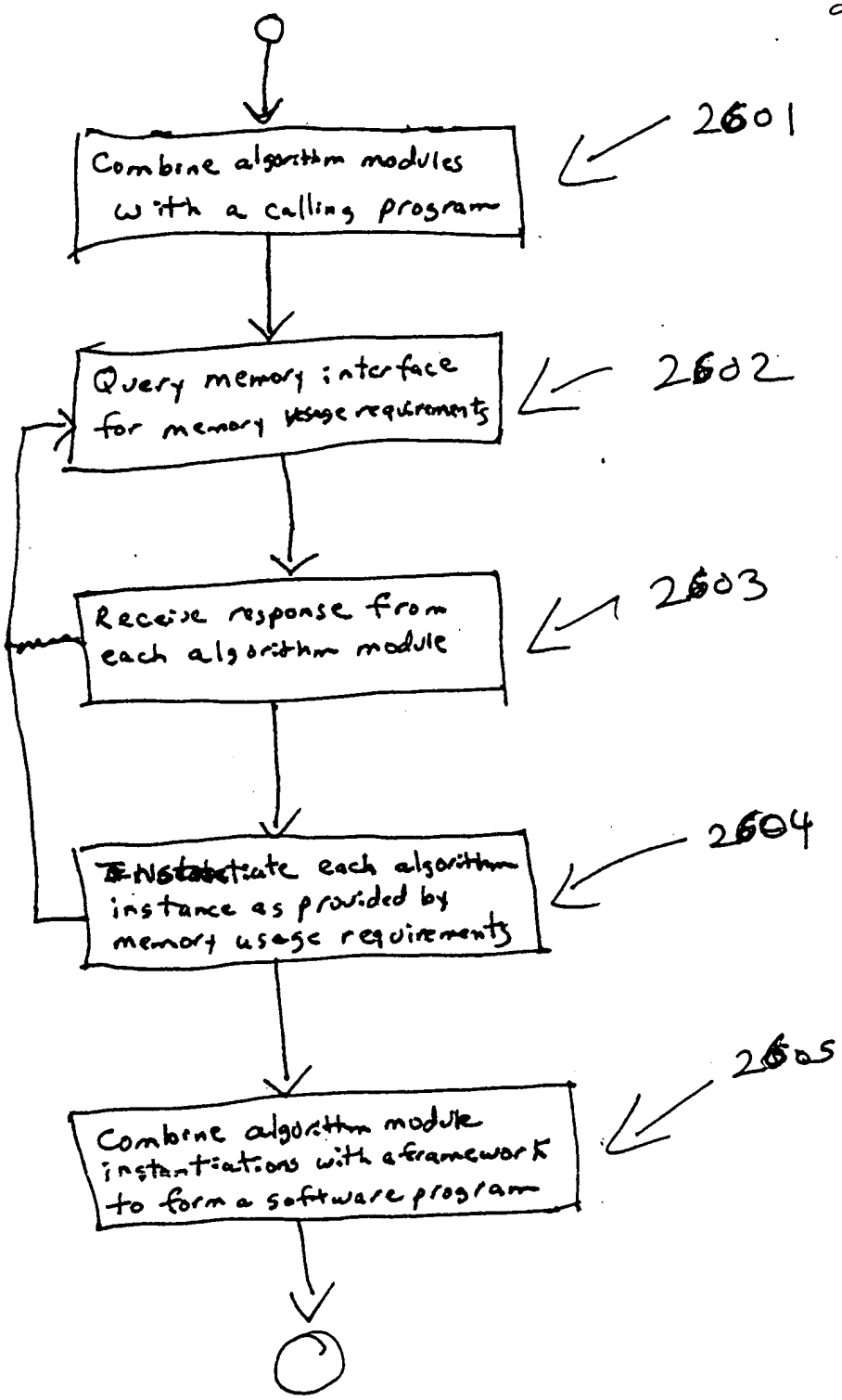

Combine algorithm modules with a calling program
2601
Query memory interface for memory usage requirements
2602
Receive response from each algorithm module
2603
Instantiate each algorithm instance as provided by memory usage requirements
2604
Combine algorithm module instantiations with a framework to form a software program
2605

Fig. 26A

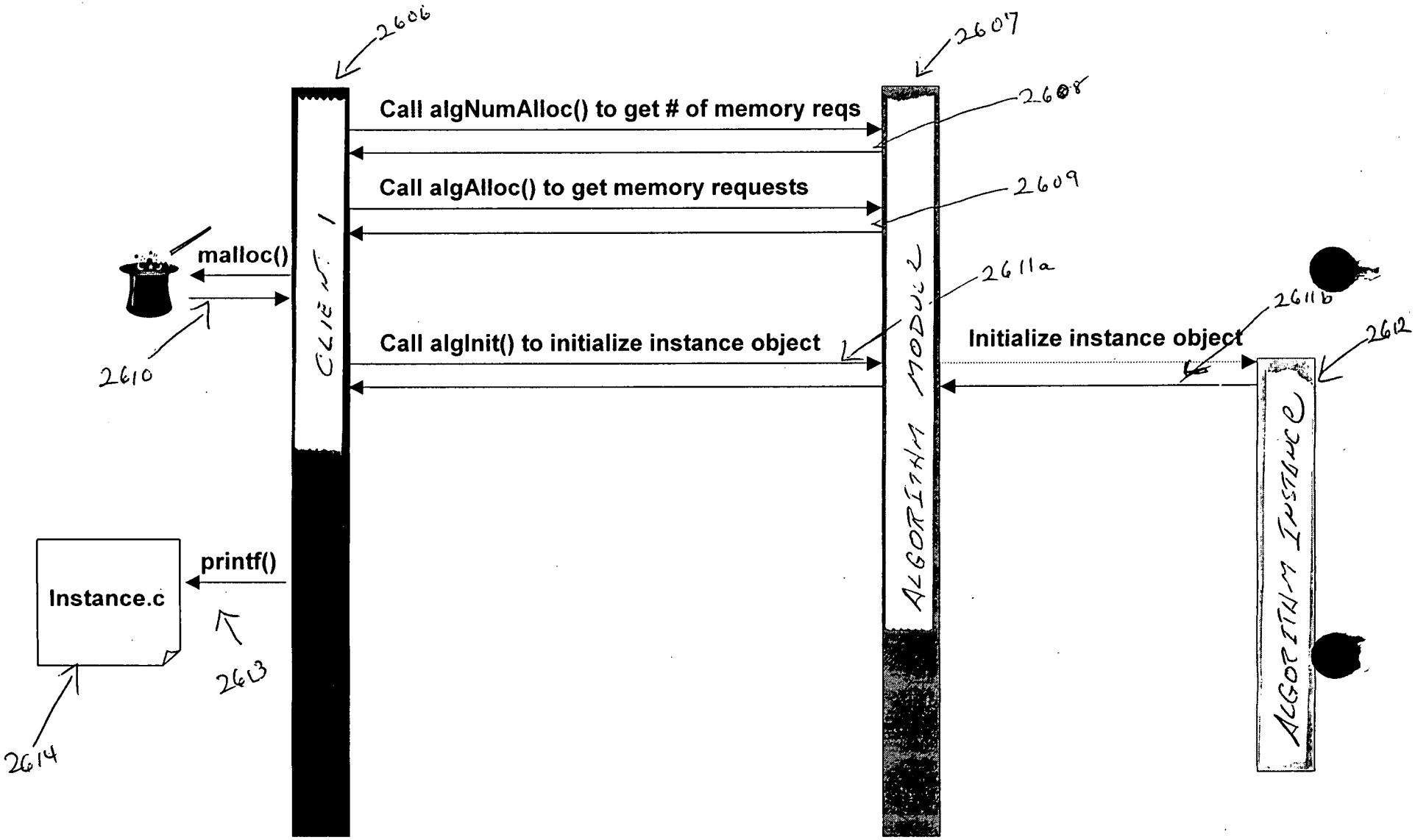
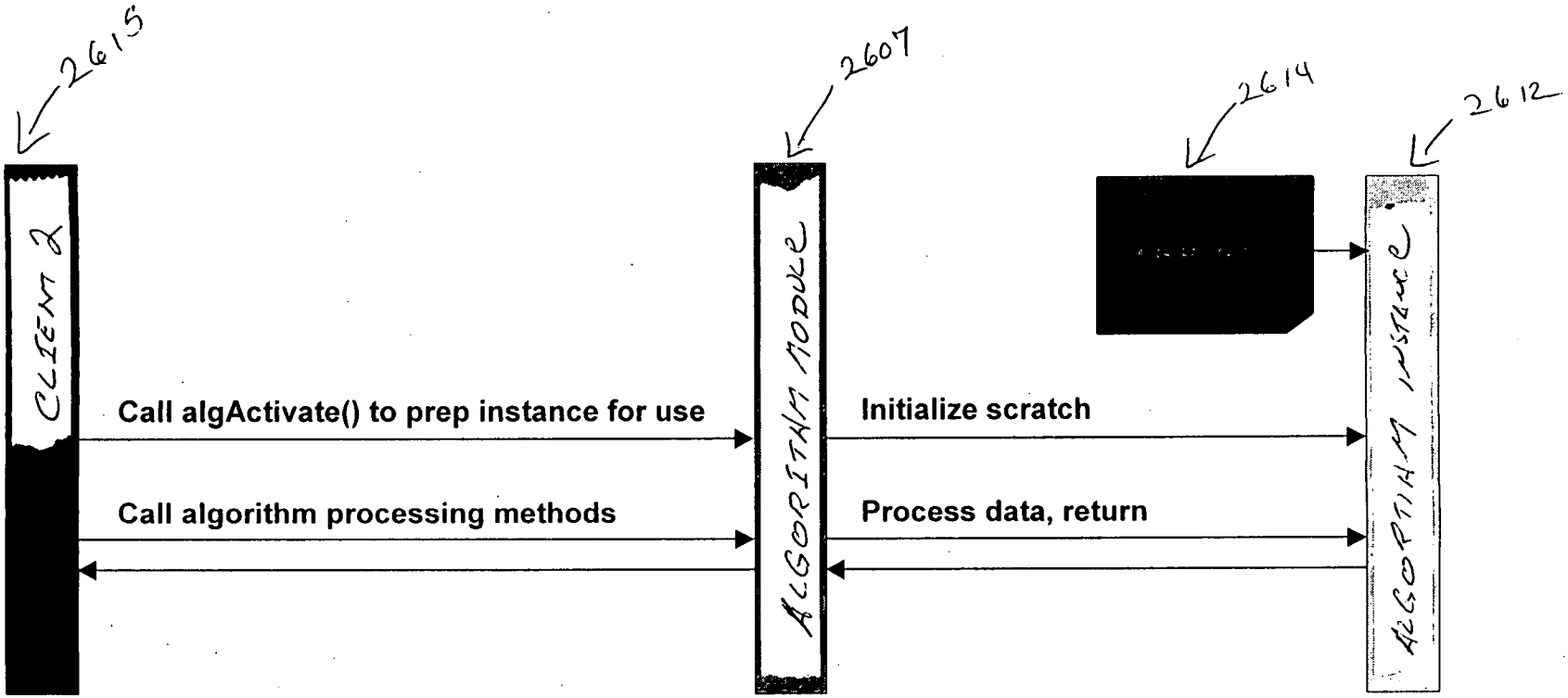

2606
2607
Call algNumAlloc() to get # of memory reqs
2608
Call algAlloc() to get memory requests
2609
malloc()
2610
2611a
Call algInit() to initialize instance object
2611b
Initialize instance object
2612
printf()
Instance.c
2613
2614
CLIENT 1
ALGORITHM MODULE
ALGORITHM INSTANCE

Fig. 26B




```
extern IALG_Handle instance;
instance->algActivate(instance);
CPY_process(instance, input, output);
```

client2.c

Fig. 26C

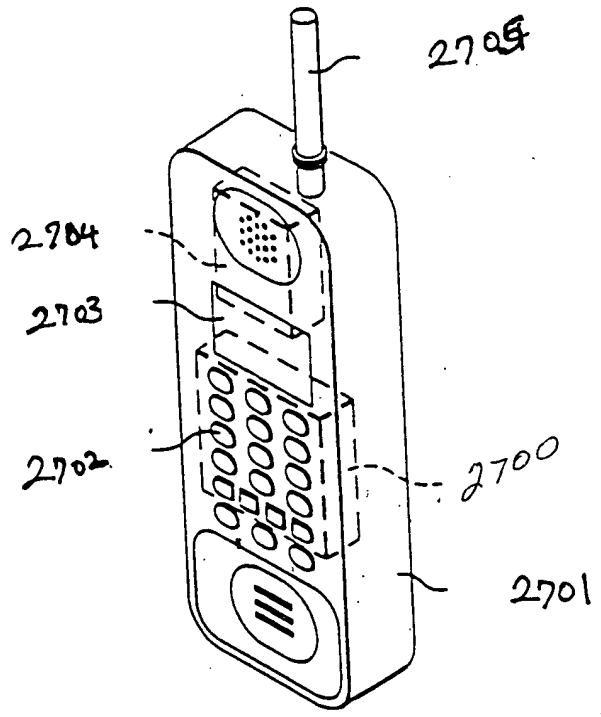


Figure 27